Joint Centre for Mesoscale Meteorology, Reading, UK

Program for PV Inversion and Modification

M. Demirtaş

Internal Report No. 82

December 1997

Met Office Joint Centre for Mesoscale Meteorology Department of Meteorology
University of Reading PO Box 243 Reading RG6 6BB United Kingdom
Tel: +44 (0)118 931 8425 Fax: +44 (0)118 931 8791
www.metoffice.com

Designed and produced by the Met Office © Crown copyright 2001 01/0240 The Met Office logo is a registered trademark.

CONTENTS

CONTENTS 1

INTRODUCTION 2

1 BACKGROUND ON THE DATA SOURCES, MDIAG PROGRAMS, DISPLAY SYSTEMS AND THE PV INVERSION TECHNIQUE 2

1.1 MDIAG PROGRAMS 3
1.2 DISPLAY PROGRAMS: MDIAG_LEVEL AND MDIAG_SURFACE 4
1.3 PC DISPLAY SYSTEM: DISP 4

2 PV INVERSION ROUTINE: MPVINVRE.FOR 4

3 USING THE PROGRAMS FOR SIMPLE PV INVERSION 5

3.1 MDIAG_BEFORE_PVINV.FOR 8
3.2 MAIN PV INVERSION PROGRAM: MPVINVRE.FOR 9
3.3 MDIAG_AFTER_PVINV.FOR 10

4 USING THE PROGRAMS FOR PV MODIFICATIONS 12

4.1 MDIAG_BEFORE_PVINV.FOR 14
4.2 MAIN PV INVERSION PROGRAM 15
4.3 MDIAG_AFTER_PVINV.FOR 15

5 PROGRAMS FOR DISPLAYING RESULTS ON THE PRESSURE AND ISENTROPIC/PV SURFACES 17

5.1 MDIAG_LEVEL_PVINV.FOR 17
5.2 MDIAG_SURFACE_PVINV.FOR 18

APPENDICES 20

A LIST OF PROGRAMS AND RELATED FILES IN DIRECTORY USER2:[DEMIRTAS.LMDPVINV] 20

B. MDPVINVRE.COM 21

C MDIAG_PARAMS_FULL.DEF 25

REFERENCES 27

Introduction

The aim of this documentation is to help users to run the potential vorticity inversion program and associated programs. Guidance is outlined to describe and to use various programs for the potential vorticity (PV) inversion and modifications. Background on the data sources, model diagnostics (MDIAG) programs and the display system is highlighted in the first section. A brief summary of the basics of the main PV inversion program is given in the second section. Using the programs for simple PV inversion is described in the third section. If a user wants to modify PV distribution first and then make the PV inversion, the fourth section is dedicated for this purpose. After having the results of the programs, the next step is to display them. The fifth section provides information about displaying results on a pressure surface, on an isentopic surface or on a PV surface. The Appendices (A, B and C), give list of programs, detailed documents on the parameters list and a copy of a command file (MDPVINRE.COM).

1 Background on the Data Sources, Mdiag Programs, Display Systems and the PV Inversion Technique

The data used in our studies are taken from the UK Meteorological Office (hereafter UKMO) archived operational analyses and forecasts. The UKMO Unified Model (hereafter UM) is hydrostatic, and uses spherical polar coordinates. (For details see Cullen 1993.) The UKMO uses the same model for operational weather prediction in global (0.8333°x1.25° resolution, 19 levels), and regional, also known as the Limited Area Model (LAM), (0.442°x0.442°, 19 levels, 229x132 points, rotated pole at 30°N, 160°E) configurations.

The LAM data have a horizontal resolution of about 50-km, and a vertical resolution, above the boundary layer, of about 1-km. The LAM data used in our studies have been analyzed using a display system at the Joint Centre for Mesoscale Meteorology at Reading University (hereafter JCMM), called DISP. The DISP data are interpolated to

lower resolution with a horizontal resolution of about 100-km, and a vertical resolution of 100-mb. After interpolating these data onto the DISP levels, an extensive set of diagnostics are calculated.

Forecasts and analyses from the LAM have been used. Forecasts contain fields of forecast data at 3-hourly intervals from T+0 to T+48 (hours). Four forecast runs (the 0000 (hereafter FA), 0600 (hereafter FB), 1200 (hereafter FC), and 1800 (hereafter FD)) are available. Analyses are obtained every 6 hours, at 0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC. The T+3 forecast fields are used as nominal intermediate analyses at the starting time of each forecast.

1.1 MDIAG PROGRAMS

MDIAG is a set of FORTRAN programs run to compute a variety of diagnostics using UM data on regular pressure levels (100-mb for the LAM). It uses the 6 basic fields of the UM - geopotential height, temperature, wind (u,v), specific humidity (q), and vertical velocity (w) - to calculate other parameters.

There are two versions of MDIAG available at the JCMM. In this report programs run on a VAX under the VMS operating system will be documented. (For the UNIX version see Panagi and Dicks 1997.)

The MDIAG program is made from 5 FORTRAN source modules. These are:
MDIAG: Defines parameters, scaling and ranges. It reads a catalogue file (.CAT in short) and a data file (.DAT in short) which contains basic parameters (wind, temperature, vertical velocity and humidity). The program then writes out data in .DB (which contains large data output) and .ATB (which contains catalogue) files.
MTHERMO: Performs basic thermodynamic calculations.
MDIAG_CALC: Calculates dynamical parameters.
MPACK: Routines to pack and unpack data.
MQSAT: Routines to return saturation mixing ratio over ice and over water. This is used for humidity conversion.
The operational programs are kept in USER1:[MD] directory.

1.2 DISPLAY PROGRAMS: MDIAG_LEVEL AND MDIAG_SURFACE

These programs create files that can be read by DISP (see section 1.3).

- MDIAG_LEVEL: Extracts a pressure level from a .DB dataset.
- MDIAG_SURFACE: Extracts parameters onto a surface. e.g. isentropic surface.

These programs are each linked with two other FORTRAN modules:

- MPACK: Routines to pack and unpack data.
- P_FORM: Routine to make P_FORMAT data. (The output data in a format packed that can be read by DISP.)

1.3 PC DISPLAY SYSTEM: DISP

DISP is a PC based graphics program widely used at JCMM. It can read, plot, and overplot model data, satellite and radar data. The model data have to be on a polar-stereographic grid and on a constant parameter surface. (For example data on a pressure level or an isentropic surface.) The DISP area covers mid and Eastern Atlantic and the western part of Europe at 61x38 resolution; grid spacing is about 100-km. Thus a low-resolution version of LAM fields is used at JCMM. In order to provide data in a special resolution and format, the above MDIAG_LEVEL and MDIAG_SURFACE programs are used.

2 PV Inversion Routine: MPVINVRE.FOR

By using the invertibility principle for PV, one can obtain the related rotational wind and temperature fields. We use non-linear balance PV inversion (Davis and Emanuel 1991, and Ziemianski 1994). Note that the inverted winds are the rotational component of the total wind field.

Some additions and modifications have been made to the original PV inversion program, particularly to increase convergence efficiency. (For details see Demirtaş 1996.) To obtain the most efficient convergence rate of the numerical solution it has been found

that the coefficient, COEF2=[(H/L)**2], must be chosen in a way that the equations used in the PV inversion technique obey the standard synoptic scaling,

i.e. $L \approx (N/f)H$

where $N/f \approx 100$ and $H \approx 10$ km. Here N is the Brunt-Väisällä frequency ($\approx 10^{-2} s^{-1}$), and f is the coriolis parameter ($\approx 10^{-4} s^{-1}$). Various L values (100-km < L < 1000-km) have been tested with the model. It was noted that sub-synoptic scales of L from 300-km to 600-km provide the most efficient convergence rate. If any problem arises from the convergence or overflow of numbers, the user is advised to try different L values. Most of the time this solves such problems. If it does not solve the problem, the best thing to do is to change the data set. For example, if you are inverting 0000 UTC data set, try the 0600 UTC data set instead. Our studies showed that the PV inversion technique is sensitive to the data set used.

The PV inversion domain and distribution of grid points match the output of the JCMM version of the LAM. Horizontally the domain consists of 61 (in the zonal direction) by 38 (in the meridional direction) grid points with basic spacing 108.9-km. Vertically the domain consists of 9 constant pressure levels from 900-mb to 100-mb. The convergence required takes about 15 minutes on a VAXSTATION 4000/90.

The author of this documentation combined the main NPVINVRE.FOR program with PREP_FILE.FOR program in order to save space and time. This version is named as MPVINVRE.FOR.

3 USING THE PROGRAMS FOR SIMPLE PV INVERSION

The operational MDIAG main program, MDIAG_LEVEL and MDIAG_SURFACE programs, were modified in order to provide input data for the PV inversion program and to use its outputs. Note also that they all work only for one time step. The PV inversion main program and associated programs are:

- MDIAG_BEFORE_PVINV.FOR: Calculates meteorological parameters. (See section 3.1)

New options added: Extract some data for the PV inversion. (PV modification option is also available see section 4.1)

- MPVINVRE.FOR: Inverts PV and provides geopotential height, temperature and wind data
- MDIAG_AFTER_PVINV.FOR: Calculates meteorological parameters.

New options added: Replace the PV inversion outputs with the original and calculate parameters from them, and also to extract a dataset for re-runs.

- MDIAG_LEVEL_PVINV.FOR: Generates a file for a pressure level
- MDIAG_SURFACE_PVINV.FOR: Interpolates parameters onto a PV or an isentropic surface.

The above listed programs are currently kept in the user2:[demirtas.lmdpvinv] directory. A list of programs and related files in that directory is given in the Appendix A. For details and latest changes see the system manager.

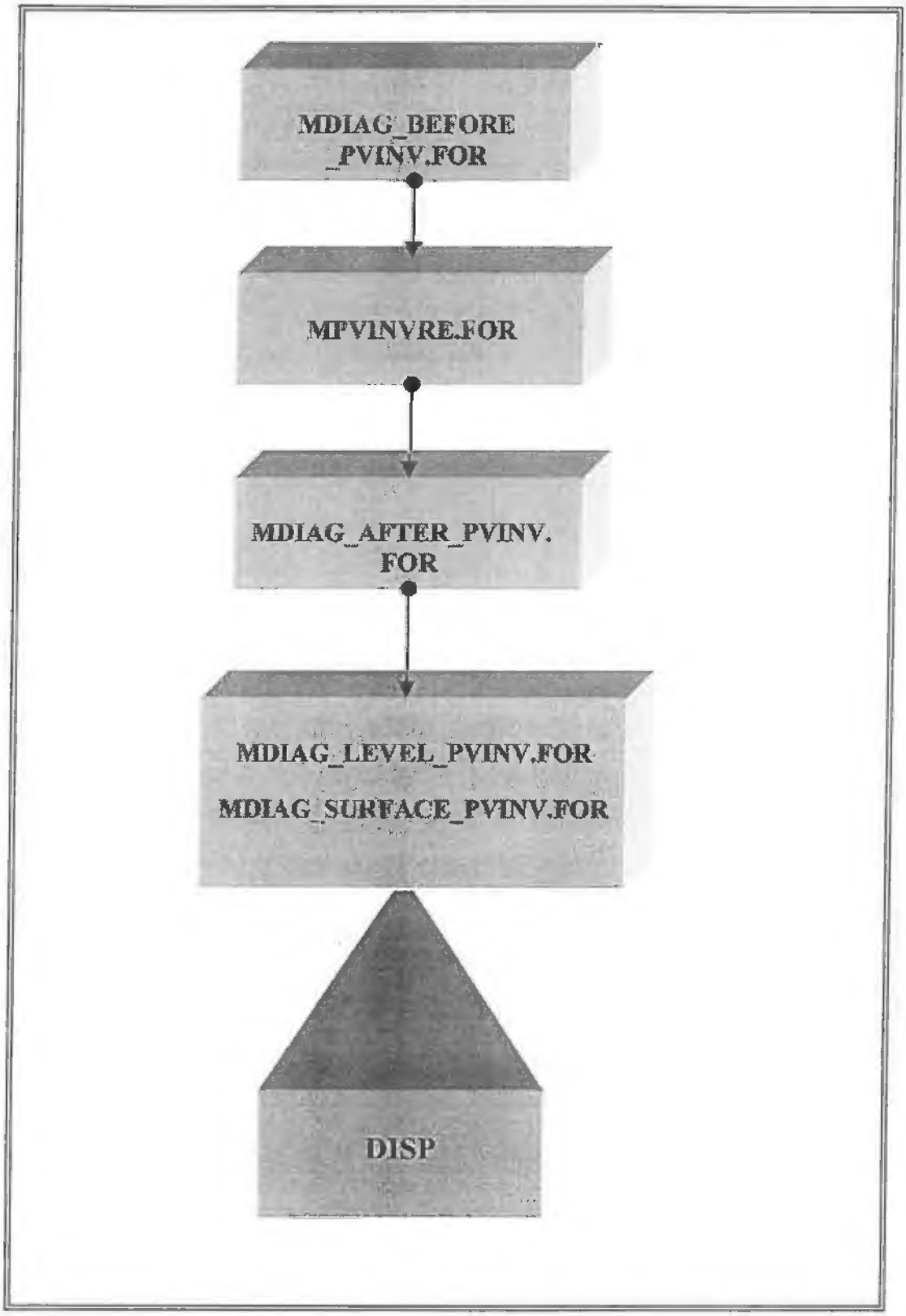

Figure (1): *A flow chart for the PV inversion related programs and the display system.*

The above programs can be run interactively, or by submitting a .com file as a batch job. In the following sections some explanations will be given how to edit the related .com files. You can also use one command file – called MDPVINV.COM - to run MDIAG_BEFORE_PVINV, MPVINVRE and MDIAG_AFTER_PVINV programs one after the other one. A copy MDPVINV.COM file is given in the Appendix B. You can edit that file and make your own runs.

3.1 MDIAG_BEFORE_PVINV.FOR

The aim of using this program is to provide geopotential height (PHI or sometimes named as FI), potential temperature (THETA), wind (u,v) and potential vorticity (PV) data for the PV inversion main program.

- ***MDIAG_BEFORE_PVINV.COM :*** Command procedures for running MDIAG_BEFORE_PVINV.FOR program.

Enter the path for MDIAG_BEFORE_PVINV.FOR program. For example:
RUN USER2:[DEMIRTAS.LMDPVINV] MDIAG_BEFORE_PVINV

Inputs required:

Line 1: Enter N to indicate that the automatic date files are not to be read. (This is because "Y" is used primarily for the automatic operational runs.)

Line 2: Enter the path for the MDIAG parameter list.
Example: USER2:[DEMIRTAS.LMDPVINV]MDIAG_PARAMS_FULL
"MDIAG_PARAMS_FULL.DEF" contains the standard parameters. (It is given in the Appendix C. Note that edited version can be made for fewer diagnostics.)

Line 3: Enter input path without the extension.
Example: USER2:[DEMIRTAS.CASE1]UA160295

[It reads UA160295.CAT and UA160295.DAT for UA160295.DB and UA160295.ATB outputs (see line 4). It also generates FI.DAT, THETA.DAT, UU.DAT, VV.DAT and PV.DAT files (see line 6) for the PV inversion program.]

Line 4: Enter the output path without the extension.
Example: USER2:[DEMIRTAS.CASE1]UA160295

Line 5: Enter a number for the time the PV inversion will be performed.
Examples: 1 for 0000 UTC, 3 for 0600 UTC, and 5 for 1200 UTC.

Line 6: Enter the output path for the FI, PTEMP, U, V and PV output files.
Example: USER2:[DEMIRTAS.CASE1]
** P.S. Path name should not be more than 24 characters. If it is bigger than this, you have to make changes in the main program.

Line 7: Type "N or n". PV changes are not going to take place at this stage. (For PV modification see sections 4 and 4.1.)

3.2 MAIN PV INVERSION PROGRAM: MPVINVRE.FOR

This program inverts PV and generates the FIinv, TEMPinv, UUinv, and VVinv datasets.

❖ ***MPVINVRE.COM***

Enter the path for the program without extension. For example:
RUN USER2:[DEMIRTAS.LMDPVINV]MPVINVRE

Inputs required:

Line 1: Enter number for iterations (NITS). The program will STOP when the convergence criteria are met. It may stop before the user defined NITS are completed.

Line 2: Enter a value for L (horizontal scale) which will be used for calculating COEF2=[(H/L)**2]. The L value can be taken between 100-1000-km.
Example: 300

Line 3: Enter "Y or y" if you want the program to run until the convergence "criteria" are satisfied. "N or n" will run the program until the user defined iteration limit.

Line 4,5,6,7,8: Enter the input path.

Example: USER2:[DEMIRTAS.CASE]FI1.DAT
USER2:[DEMIRTAS.CASE]THETA1.DAT
USER2:[DEMIRTAS.CASE]UU1.DAT
USER2:[DEMIRTAS.CASE]VV1.DAT
USER2:[DEMIRTAS.CASE]PV1.DAT

[Here 1 indicates 0000 UTC data. Note also that these are produced by the MDIAG_BEFORE_PVINV.FOR program.]

Line 9,10,11,12: Enter the output path.

Example: USER2:[DEMIRTAS.CASE]FIINV1.DAT
USER2:[DEMIRTAS.CASE]TEMPINV1.DAT
USER2:[DEMIRTAS.CASE]UUINV1.DAT
USER2:[DEMIRTAS.CASE]VVINV1.DAT

[Here 1 indicates 0000 UTC data.]

3.3 MDIAG_AFTER_PVINV.FOR

This program uses PV inversion outputs to generate other meteorological parameters. In other words, it uses PV inversion results of FIinv, TEMPinv, UUinv and VVinv and generates a .DB file and a .ATB file.

❖ *MDIAG_AFTER_PVINV.COM*

Enter the path for MDIAG_AFTER_PVINV.FOR program without extension. For example:
RUN USER2:[DEMIRTAS.LMDPVINV] MDIAG_AFTER_PVINV.FOR

Inputs required:

Line 1: Enter N to indicate that the automatic date files are not to be read.

Line 2: Enter the path for the parameter list.
Example: USER2:[DEMIRTAS.MDPVINV]MDIAG_PARAMS_FULL
[See Appendix C for details.]

Line 3: Enter input path without the extension.
Example: USER2:[DEMIRTAS.CASE1]UA160295
[Note that this is the original data set.]

Line 4: Enter the output path without the extension.
Example: USER2:[DEMIRTAS.CASE]ICASE
[Here "I" is used to indicate that this is PV inversion result.]

Line 5,6,7,8: Enter the input path and file names.
Example: USER2:[DEMIRTAS.CASE]FIINV1.DAT
USER2:[DEMIRTAS.CASE]TEMPINV1.DAT
USER2:[DEMIRTAS.CASE]UUINV1.DAT
USER2:[DEMIRTAS.CASE]VVINV1.DAT
[Here 1 indicates 0000 UTC data. Note that these are MPVINVRE.FOR program outputs.]

Line 9: Enter a number that corresponds with PV inversion time.
Examples: 1 for 0000 UTC, 3 for 0600 UTC, and 5 for 1200 UTC.

[Note that this has to be same as the one specified for MDIAG_BEFORE_PVINV.FOR program.]

Line 10: Type "Y or y" if you want to extract some data for re-runs. When you say "Y or y" be sure that you have defined related parameters and locations.

Line 11: Enter the output path and the file name.
Example: USER2:[DEMIRTAS.CASE1]C1.DAT
[This is the file that contains the data for re-runs. See section 4.3.]

4 USING THE PROGRAMS FOR PV MODIFICATIONS

The user should define the locations and magnitudes of PV values within the main program. The relevant section for this task has been shown with comment lines in the MDIAG_BEFORE_PVINV.FOR program. In that section the user needs to specify the following:
(1) horizontal locations with **(I,J grid points)**, (2) vertical location with a pressure level code (see table 1 for details), and (3) new PV values.

1. How to convert DISP x,y distances into the MDIAG **I,J** locations.

    I=(X_Distance/101.6)+1

    J=(Y_Distance/101.6)+1

Here 101.6-km is the DISP grid spacing. Since the origin starts with (0,0) in the DISP, you need to add 1 to get the same location in the MDIAG. Figure 2 presents the DISP LAM area and crosses show some PV modification points.

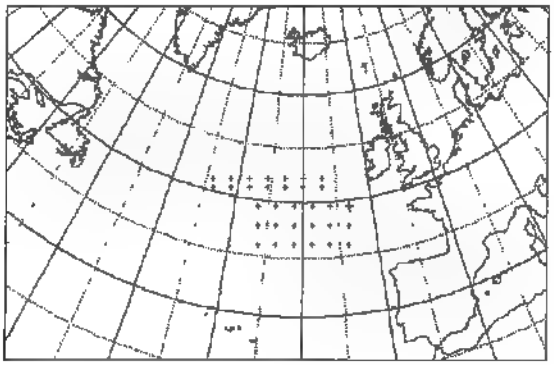

***Figure (2):** LAM area in DISP and some locations of the data provided for a re-run.*

2. How the pressure levels are coded.

Main MDIAG program reads pressure levels in the following coding.

CODES	LEVELS (mb)
1	1000
2	900
3	800
4	700
5	600
6	500
7	400
8	300
9	200
10	100

***Table (1):** Pressure levels and coding system in the MDIAG main program.*

3. How to choose new PV values.

This depends on the user's aims. If you want to modify PV distribution with respect to the Meteosat water vapour imagery, you may be interested to see the JCMM Internal Report 71 (Demirtaş and Thorpe 1997).

4.1 MDIAG_BEFORE_PVINV.FOR

This is the same as the program described in section (3.1). The aim here is to use it for altering the original PV distributions.

Points to note: If you are using MDIAG_BEFORE_PVINV for PV modifications, it is better to copy the program into another directory and re-arrange it in there. Otherwise, you may overwrite or get confused with other versions.

❖ ***MDIAG_BEFORE_PVINV.COM***

Enter the path for Mdiag1.for program. For example:
RUN USER2:[DEMIRTAS.CASE1.T1]MDIAG_BEFORE_PVINV

Inputs required:

Line 1: Enter N to indicate that the automatic date files are not to be read.
Line 2: Enter the path for the parameter list.
Example: USER2:[DEMIRTAS.LMDPVINV]MDIAG_PARAMS_FULL

Line 3: Enter input path without the extension.
Example: USER2:[DEMIRTAS.CASE1]UA160295

Line 4: Enter the output path without the extension.
Example: USER2:[DEMIRTAS.CASE1.T1]MD160295
[Note that "MD" is used here to indicate that this is a "modified dataset".]

Line 5: Enter a number that corresponds with PV inversion time.
Examples: 1 for 0000 UTC, 3 for 0600 UTC, and 5 for 1200 UTC.

Line 6: Enter the output path for the FI, PTEMP, U, V and PV.
Example: USER2:[DEMIRTAS.CASE1.T1]
** P.S. The path name should not be more than 24 characters. If it is bigger than this, you have to make changes in the main program.

Line 7: Type "Y or y" in order to direct the program to change original PV distribution.

4.2 MAIN PV INVERSION PROGRAM

This is the same as the one described in the section (3.2).

4.3 MDIAG_AFTER_PVINV.FOR

This is the same as the one described in the section (3.3). The only difference is that it provides additional datasets, based on the user defined PV modifications, for a re-run. In order to get these datasets, you should specify within the main program parameters that you need and locations (I,J grid points). The datasets have the following format.

Lat (°N)	Lon (°E)	Pressure (mb)	Temp (°C)	U(m/s)	V(m/s)

Table (2): *Output data format.*

Points to note: If you are using the MDIAG_AFTER_PVINV for PV modifications, it is better to copy the program into another directory and re-arrange it in there. Otherwise, you may overwrite or get confused with other versions.

❖ *MDIAG_AFTER_PVINV.COM*

Enter the path for MDIAG_AFTER_PVINV.FOR program without extension. For example: RUN USER2:[DEMIRTAS. LMDPVINV]MDIAG_AFTER_PVINV

Inputs required:

Line 1: Enter N to indicate that the automatic date files are not to be read.

Line 2: Enter the path for the parameter list.
Example: USER2:[DEMIRTAS.LMDPVINV]MDIAG_PARAMS_FULL
Line 3: Enter input path without the extension.
Example: USER2:[DEMIRTAS.CASE1]UA160295

Line 4: Enter the output path without the extension.
Example: USER2:[DEMIRTAS.CASE1.T1]IM160295
[Note that here "T" is used to indicate that this is the PV inversion result.]

Line 5,6,7,8: Enter the input path and file names.
Example: USER2:[DEMIRTAS.CASE1.T1]FIINV1.DAT
USER2:[DEMIRTAS.CASE1.T1]TEMPINV1.DAT
USER2:[DEMIRTAS.CASE1.T1]UUINV1.DAT
USER2:[DEMIRTAS.CASE1.T1]VVINV1.DAT
[Here 1 represents 0000 UTC data time.]

Line 9: Enter a number that corresponds with PV inversion time.
Examples: 1 for 0000 UTC, 3 for 0600 UTC, and 5 for 1200 UTC.

Line 10: Type "Y or y" if you want to extract data for re-runs. When you say "Y or y" be sure that you have defined related parameters and locations.

Line 11: Enter the output path and the file name, if you typed "Y or y" in the previous line.

Example: USER2:[DEMIRTAS.CASE1.T1]MDC1.DAT

[Here "MD" is used to indicate that these data are obtained from the PV modifications.]

5 PROGRAMS FOR DISPLAYING RESULTS ON THE PRESSURE AND ISENTROPIC/PV SURFACES

The following sections explain MDIAG_LEVEL_PVINV and MDIAG_SURFACE_PVINV programs and their .com files. They are needed for preparing the data for DISP.

5.1 MDIAG_LEVEL_PVINV.FOR

This program extracts data on a pressure level. The main difference between this version and the standard one is that this one works only for a user defined time step that corresponds to PV inversion time.

❖ *MDIAG_LEVEL_PVINV.COM*

Enter the path name without extension. For example:

RUN USER2:[DEMIRTAS.LMDPVINV]MDIAG_LEVEL_PVINV

Inputs required:

Line 1: Enter N to indicate that the automatic date files are not to be read.

Line 2: Enter input path without the extension.

Example: USER2:[DEMIRTAS.CASE1]UA160295

Line 3: Enter the output path without the extension.

Example: USER5:[MERAL.CASES.CASE1]UA160295

[Note that these results should be put into a directory that can be seen by a PC. For details see the system manager.]

Line 4: Enter a number for pressure level (1,2,3,4,5,6,7,8,9,10)
E.g. 1 is for 100-mb, 10 is for 1000-mb

Line 5: Total number of parameters required.
E.g.: 4 (Say you want geopotential height, u,v and PV, then the total is 4)

Line 6+n: Parameter numbers
Examples: 1 (for geopotential height)
3 (for u)
4 (for v)
16 (for PV)
[See also Appendix C for the parameter list.]

5.2 MDIAG_SURFACE_PVINV.FOR

This interpolates parameters onto a surface. The main difference between this version and the standard one is that this one works only for a user defined time step that corresponds to PV inversion time.

❖ *MDIAG SURFACE_PVINV.COM*

Enter the path name without extension. For example:
RUN USER2:[DEMIRTAS.LMDPVINV]MDIAG_SURFACE_PVINV

Inputs required:

Line 1: Enter N to indicate that the automatic date files are not to be read.
Line 2: Enter input path without the extension.

Example: USER2:[DEMIRTAS.CASE1]UA160295

Line 3: Enter the output path without the extension.

Example: USER5:[MERAL.CASES.CASE1]UA160295

[Note that these results are put into the "cases" directory in order to be retrieved by a PC!]

Line 4: Parameter for choice of a surface.

E.g. 6 for an isentropic, 16 for an iso-PV surface.

Line 5: Value for that parameter.

E.g. 42 for 315K isentropic surface, 2 for PV=2 iso-PV surface.

Line 6: Title for the surface chosen.

E.g. 315K for the isentropic surface, PV=2 for the PV=2 iso-PV surface.

Line 7: Total number of parameters required.

E.g.: 4 (Say you want geopotential height, u,v and PV)

Line 8+n: Parameter numbers

Examples: 1 (for geopotential height)
3 (for u)
4 (for v)
16 (for PV)

[See also Appendix C for the parameter list.]

Acknowledgements: The author thanks Nigel Roberts, Sean Swarbrick, Andy Macallan and Andy White for their constructive comments on this documentation.

APPENDICES

A LIST OF PROGRAMS AND RELATED FILES IN DIRECTORY USER2:[DEMIRTAS.LMDPVINV]

```
CONVRT.FOR;29                9  25-APR-1995 15:54:30.47  (RWED,RWED,RE,)
CORIOLIS.DAT;1              73  16-AUG 1994 10:55:55.34  (RWED,RWED,RE,)
DEX.DAT;1                    1  19-SEP-1994 08:33:53.29  (RWED,RWED,RE,)
MAPFAC.DAT;1                73  16-AUG-1994 10:55:56.99  (RWED,RWED,RE,)
MDIAG.LIS;1                  6  24-OCT 1997 10:11:53.01  (RWED,RWED,RE,)
MDIAG_AFTER_PVINV.COM;3
                             5  19-DEC-1997 10:10:07.71  (RWED,RWED,RE,)
MDIAG_AFTER_PVINV.EXE;3
                           240   7-NOV-1997 10:18:07.01  (RWED,RWED,RE,)
MDIAG_AFTER_PVINV.FOR;6
                            88  19-DEC-1997 09:55:09.38  (RWED,RWED,RE,)
MDIAG_AFTER_PVINV.OBJ;3
                            54   7-NOV-1997 10:17:52.09  (RWED,RWED,RE,)
MDIAG_BEFORE_PVINV.COM;3
                             4  19-DEC-1997 09:52:19.50  (RWED,RWED,RE,)
MDIAG_BEFORE_PVINV.EXE;1
                           233  15-OCT-1997 11:42:31.77  (RWED,RWED,RE,)
MDIAG_BEFORE_PVINV.FOR;5
                            76  19-DEC-1997 09:50:01.08  (RWED,RWED,RE,)
MDIAG BEFORE_PVINV.OBJ;1
                            45  15-OCT-1997 11:41:52.93  (RWED,RWED,RE,)
MDIAG LEVEL_PVINV.COM;64
                             1  12 NOV 1997 12:48:59.81  (RWED,RWED,RE,)
MDIAG_LEVEL_PVINV.EXE;12
                            23  16 OCT 1997 13:17:43.56  (RWED,RWED,RE,)
MDIAG_LEVEL_PVINV.FOR;9
                            24  16 OCT 1997 13:17:15.95  (RWED,RWED,RE,)
MDIAG_LEVEL_PVINV.OBJ;10
                            15  16-OCT-1997 13:17:36.60  (RWED,RWED,RE,)
MDIAG_PARAMS.DEF;3           4  24-OCT-1997 10:22:38.19  (RWED,RWED,RE,)
MDIAG_PARAMS.FULL;8
                             3  31-MAR-1996 16:36:49.87  (RWED,RWED,RE,)
MDIAG_SURFACE_PVINV.COM;21
                             4  10-NOV-1997 14:59:10.81  (RWED,RWED,RE,)
MDIAG_SURFACE_PVINV.EXE;26
                            27  16-OCT-1997 14:10:26.26  (RWED,RWED,RE,)
MDIAG_SURFACE_PVINV.FOR;22
                            31  16-OCT-1997 14:10:14.98  (RWED,RWED,RE,)
MDIAG_SURFACE_PVINV.OBJ;26
                            19  16-OCT-1997 14:10:20.14  (RWED,RWED,RE,)
MDPVINV.COM;12              17  19-DEC-1997 10:14:11.17  (RWED,RWED,RE,)
MPACK.OBJ;1                  4  15 OCT 1997 13:27:32.83  (RWED,RWED,RE,)
NPVINVRE.COM;40              5  12-SEP-1997 16:13:20.45  (RWED,RWED,RE,)
NPVINVRE.EXE;16             57  11 SEP 1997 14:20:51.47  (RWED,RWED,RE,)
NPVINVRE.FOR;27            110  11-SEP-1997 14:20:34.01  (RWED,RWED,RE,)
NPVINVRE.OBJ;20             45  11-SEP-1997 14:20:37.48  (RWED,RWED,RE,)
P_FORM.OBJ;2                 8  15-OCT-1997 13:27:29.98  (RWED,RWED,RE,)
TMP.LIS;1                    0  19 DEC-1997 10:15:05.29  (RWED,RWED,RE,)
Total of 31 files, 1307 blocks.
```

B. MDPVINVRE.COM

```
$! MDPVINVRE.COM
$! ==============
$!
$! Command procedures to invert PV and create display files.
$!
$! There are mainly 3 programs that have to be run for this purpose. The
$! following documentation was prepared to help users how to run each
$! program. (Meral Demirtas, 12 September 1997)
$!
$!=====================================================================
$! I. LINES FOR MDIAG1.FOR (It is for getting data for PV inversion.)
$!          New Name: MDIAG_BEFORE_PVINV
$! ===========                ==============================
$!
$!  Run MDIAG1. This provides FI, TEMP, WIND, and PV data for inversion
$!              and generates 2 files (.DB and .ATB).
$!              The program can also be used modifying PV distribution.
$!
$!       [*** Please note that this MDIAG version is different than the
$!            others. It is run only for one time step! ***]
$!
$!     line 1 :Y if reading filename from MDATE.DAT, N if not. Usually
$!             only the routine daily run reads from FMDATE.DAT so use N
$!
$!     line 2 : Enter the path for the parameter list. Usually
$!              MDIAG_PARAMS.DEF for the standard parameters.
$!
$!     line 3 : If reading from MDATE.DAT enter input dataset directory.
$!              If not reading from MDATE.DAT enter input path without
$!              the extension e.g. USER2:[FMOUTPUT]FMSTORMA
$!
$!     line 4 : If reading from MDATE.DAT enter output directory name.
$!              If not reading from MDATE.DAT enter output path without
$!              the extension e.g. USER2:[FMOUTPUT]FMSTORMA
$!
$!     line 5: Enter a number for PV inversion data time.
$!             e.g. 3 for 0600 UTC. (1 for 0000 UTC, 5 for 1200 UTC)
$!
$!     line 6: Enter output dataset directory for the inversion.
$!             e.g. user7:[demirtas.11dec case]
$!      ** P.S. Directory name should not be more than 24 characters.
$!
$!     line 7: If you want to make PV modifications type "Y or y".
$!
$! ---------------------------------------------------------------
$!
$! An example:
$!
$! RUN USER2:[demirtas.Lmdpvinv]MDIAG_BEFORE_PVINV
$! N
$! USER2:[demirtas.lmdpvinv]MDIAG_PARAMS.FULL
$! USER2:[demirtas.iop12]ua080297
$! USER2:[demirtas.fc1]rfc1
$! 1
$! user2:[demirtas.fc1]
$! y
$!
```

```
$!=================
$! II.  LINES FOR PVINVERSION PROGRAM: NPVINVRE.FOR
$!=================
$!
$!    NPVINVRE.FOR inverts PV and generates FIinv, TEMPinv, UUinv, VVinv
$'    data set to be used in the other MDIAG.FOR program.
$!
$! Line 8. Enter number for iterations will be used in the program.
$! There is also test procedure that stops the program before reaching
$! NITS value. e.g. NITS=500 but the program may finish when NITS=150
$!
$! Line 9. Enter a value for L which will be used in COEF2=[(H/L)**2].
$! This is the coefficient varies between 0.001 to 0.0003 depending on
$!         the case study. [H-10km.]
$!
$! Line 10. Enter `Y'if the program is wanted to stop according to
$! test criteria. `N' or `n' will run the program until a user defined
$! iterations ends.
$!
$! Lines 11,12,13,14,15. Enter input file names for FI,U,V,PV and THETA.
$!
$!            e.g. user7:[demirtas.case1]FI3.DAT
$!                 user7:[demirtas.case1]UU3.DAT
$!                 user7:[demirtas.case1]VV3.DAT
$!                 user7:[demirtas.case1]PV3.DAT
$!                 user7:[demirtas.case1]TH3.DAT
$!
$! (Here 3 represents 00600 UTC data time.)
$!  e.g. 1 is for 0000 UTC, 5 is for 1200 UTC.
$!
$! Lines 16,17,18,19:
$!                      Enter output directory and file
$!                      names for U,V,FI,temperature:
$!
$!                   e.g.  user7:[demirtas.md]fiinv.dat
$!                         user7:[demirtas.md]tempinv.dat
$!                         user7:[demirtas.md]uinv.dat
$!                         user7:[demirtas.md]vinv.dat
$!------------------
$! An example:
$!
$! RUN USER2:[demirtas.lmdpvinv]NPVINVRE
$! 500
$! 400
$! y
$! user2:[demirtas.fc1]fi1.dat
$! user2:[demirtas.fc1]uu1.dat
$! user2:[demirtas.fc1]vv1.dat
$! user2:[demirtas.fc1]pv1.dat
$! user2:[demirtas.fc1]th1.dat
$! user2:[demirtas.sil]fiinv1.dat
$! user2:[demirtas.sil]tempinv1.dat
$! user2:[demirtas.sil]uuinv1.dat
$! user2:[demirtas.sil]vvinv1.dat
```

```
$!=============================================================
$!III. LINES FOR MDIAG2.FOR (It is for using data for PV inversion data)
$!         New Name: MDIAG_AFTER_PVINV
$!=============================================================
$!
$!    Run MDIAG2. uses FIinv, TEMPinv, UUinv and VVinv data
$!                  and generates 2 files (.DB and .ATB).
$!                  The program can also provide data for re-runs.
$!
$!       [*** Please note that this MDIAG version is different than the
$!                others. It is run only for one time step! ***]
$!
$!    line 20 :Y if reading filename from MDATE.DAT, N if not. Usually
$!             only the routine daily run reads from FMDATE.DAT so use N
$!
$!    line 21 : Enter the path for the parameter list. Usually
$!              MDIAG PARAMS.DEF for the standard parameters.
$!
$!    line 22 : If reading from MDATE.DAT enter input dataset directory.
$!              If not reading from MDATE.DAT enter input path without
$!              the extension e.g. USER2:[FMOUTPUT]FMSTORMA
$!
$!    line 23 : If reading from MDATE.DAT enter output directory name.
$!              If not reading from MDATE.DAT enter output path without
$!              the extension e.g. USER2:[FMOUTPUT]FMSTORMA
$!
$!    lines 24,25,26,27: Enter the input dataset directory names
$!                       of FI,temp,U,V
$!
$!                  e.g. user7:[demirtas.md]FI1.dat
$!                       user7:[demirtas.md]uu1.dat
$!                       user7:[demirtas.md]vv1.dat
$!                       user7:[demirtas.md]th1.dat
$!
$!    line 28: Enter a number that corresponds with PV inversion time.
$!             e.g. 3 for 0600 UTC. (1 for 0000 UTC, 5 for 1200 UTC)
$!
$!    line 29: If you want to get data for re-runs type "Y or y".
$!
$!    line 30: Enter a file name for a re run dataset.
$!              e.g. user2:[demirtas.case1]Case1.dat
$!
=============================================================
$! An example:
$!
$! RUN USER2:[demirtas.Lmdpvinv]MDIAG_AFTER_PVINV
$! N
$! USER2:[demirtas.lmdpvinv]MDIAG_PARAMS.FULL
$! USER2:[demirtas.iop10]ua080297
$! USER2:[demirtas.case1]ic1t2
$! user2:[demirtas.case1]fiinv1.dat
$! user2:[demirtas.case1]tempinv1.dat
$! user2:[demirtas.case1]uuinv1.dat
$! user2:[demirtas.case1]vvinv1.dat
$! 1
$! y
$! user2:[demirtas.case1]case1.dat
```

```
$!-------------------------------------------------------------------
$ RUN USER2:[demirtas.lmdpvinv]MDIAG_BEFORE_PVINV
N
USER2:[demirtas.lmdpvinv]MDIAG_PARAMS.FULL
USER2:[demirtas.iop10]ua030297
USER2:[demirtas.lmdpvinv]msil1
5
user2:[demirtas.lmdpvinv]
Y
$!
$! optional! If you do not wand the following files then remove ! sign.
$! So that the system automatically will delete them.
$!
$! DELETE /NOCONFIRM [demirtas.case1]test.ATB;*
$! DELETE /NOCONFIRM [demirtas.case1]test.DB;*
$!
$ RUN USER2:[demirtas.lmdpvinv]NPVINVRE
500
400
Y
user2:[demirtas.lmdpvinv]fi5.dat
user2:[demirtas.lmdpvinv]uu5.dat
user2:[demirtas.lmdpvinv]vv5.dat
user2:[demirtas.lmdpvinv]th5.dat
user2:[demirtas.lmdpvinv]pv5.dat
user2:[demirtas.lmdpvinv]fiinv5.dat
user2:[demirtas.lmdpvinv]tempinv5.dat
user2:[demirtas.lmdpvinv]uuinv5.dat
user2:[demirtas.lmdpvinv]vvinv5.dat
$ RUN USER2:[demirtas.lmdpvinv]MDIAG_AFTER_PVINV
N
USER2:[demirtas.lmdpvinv]MDIAG_PARAMS.FULL
USER2:[demirtas.iop10]ua030297
USER2:[demirtas.mdpvinv]msil2
user2:[demirtas.mdpvinv]fiinv5.dat
user2:[demirtas.mdpvinv]tempinv5.dat
user2:[demirtas.mdpvinv]uuinv5.dat
user2:[demirtas.mdpvinv]vvinv5.dat
5
Y
user2:[demirtas.lmdpvinv]mdsil.dat
$!
$ exit
```

C MDIAG_PARAMS_FULL.DEF

```
================================================================================
The first 5 lines are comments. Then index numbers are read in
(FORMAT I2).
* When 99 is reached no more data is read in.
*================================================================================
 1  Geopotential height
 2  Temperature
 3  U component
 4  V component
 5  Relative Humidity(ice)
 6  Potential Temperature
 7  Equivalent potential temperature
 9  Humidity mixing ratio
10  Sat Equ Pot Temp
11  du/dp
12  dv/dp
13  d@/dp
14  d@e/dp
15  div V
16  Dry PV
17  Moist PV
18  Geostrophic U
19  Geostrophic V
20  Wind strength
21  Q1
22  Q2
23  div Q
24  Absolute vorticity
25  Vertical velocity
26  dv/dz-dvg/dz
27  du/dz-dug/dz
28  dug/dp
29  dvg/dp
30  Momentum
31  Magnitude geostrophic deformation
32  EW cpt, Gedef axis
33  NS cpt, Gedef axis
34  Mag Grad(ThetaE)
35  EW cpt, Grad(ThW)
36  NS cpt, Grad(ThW)
37  Geo Defmn wrt ThW
38  Relative vorticity
39  Geostrophic relative vorticity
40  Wind direction
41  Theta-W
42  U ageostrophic
43  V ageostrophic
44  Mag Grad(Th)
45  EW component, Grad(Th)
46  NS component, Grad(Th)
47  Q1 tangtl to Theta
48  Q2 tangtl to Theta
49  Div (Q tgtl)
50  Q1 normal to Theta
```

```
51  Q2 normal to Theta
52  Div (Q nrml)
53  Relative Humidity(wat)
54  Inv diab forcing
55  Inv divQ & diab
56  Inv lap of divQ
57  Invlap divQ scaled
58  800-600mb Inv divQ
59  600-100mb Inv divQ
60  1000-800mb InvdivQ
61  Frontal Zones (ThW)
62  Front  ^DelSqd(ThW)
63  Front -DelSqd(ThW)
64  Front |grad(ThW)|
65  Front Speed km/3hr
66  ThW-advection *1E4
67  Geost ThW-advn *1E4
68  Frontal Zones (Th)
69  Front -^delsqd(Th)
70  Front -delsqd(Th)
71  Front |grad(Th)|
72  Frnt Spd(Th)km/3hr
73  Th advection *1e4
74  Geost Th-advn *1e4
75  Shear Rel Vort x1E5
76  Jet Stream "angle"
99  NO MORE PARAMETERS
*-------------------------------------------------
```

References

Cullen, M. J. P. (1993): The Unified Forecast/Climate Model. *Meteorol. Mag.*, **122**, 81-94

Davis, C. A., and Emanuel, K. A. (1991): Potential vorticity diagnostics of cyclogenesis. *Mon. Wea. Rev.* **119**, 1929-1953

Demirtaş, M. and Thorpe, A. J. (1996): A new method for short-range weather forecasting - quality control and intervention. *Seventh Conference on Mesoscale Processes, 9-13 September 1996, Reading UK, pp: 396-398.*

Demirtaş, M. (1996): Sensitivity of Short-Range Forecasts to Local Potential Vorticity Modifications, *Ph.D. Thesis*, University of Reading, *227pp.*

Panagi, P., and Dicks, E. (1997): Met. Office Unified Model data diagnostics, graphics process, and other observational data available from the JCMM through the aegis of the Universities Weather Research Network UWERN, *JCMM Internal Report, No: 69, University of Reading.*

Ziemianski, M. (1994): Potential Vorticity Inversion, *JCMM Internal Report, No: 39, University of Reading.*

CURRENT JCMM INTERNAL REPORTS

This series of JCMM Internal Reports, initiated in 1993, contains unpublished reports and also versions of articles submitted for publication. The complete set of Internal Reports is available from the National Meteorological Library on loan, if required.

1. **Research Strategy and Programme**
   K A Browning et al
   January 1993

2. **The GEWEX Cloud System Study (GCSS)**
   GEWEX Cloud System Science Team
   January 1993

3. **Evolution of a mesoscale upper tropospheric vorticity maximum and comma cloud from a cloud-free two dimensional potential vorticity anomaly**
   K A Browning
   January 1993

4. **The Global Energy and Water Cycle**
   K A Browning
   July 1993

5. **Structure of a midlatitude cyclone before occlusion**
   K A Browning and N Roberts
   July 1993

6. **Development in Systems and Tools for Weather Forecasting**
   K A Browning and G Szejwach
   July 1993

7. **Diagnostic study of a narrow cold frontal rainband and severe winds associated with a stratospheric intrusion**
   K A Browning and R Reynolds
   August 1993

8. **Survey of perceived priority issues in the parametrizations of cloud-related processes in GCMs**
   K A Browning
   September 1993

9. **The Effect of Rain on Longwave Radiation**
   I Dharssi
   September 1993

10. **Physical Cloud Microprocesses - A Description of the Parametrization used in the Large Eddy Model**
    H Swann
    July 1994

11. **An Appreciation of the Meteorological Research of Ernst Kleinschmidt**
A J Thorpe
May 1992

12. **Potential Vorticity of Flow Along the Alps**
A J Thorpe, H Volkert and Dietrich Heimann
August 1992

13. **The Representation of Fronts**
A J Thorpe
January 1993

14. **A Parametrization Scheme for Symmetric Instability: Test for an Idealised Flow**
C S Chan and A J Thorpe
February 1993

15. **The Fronts 92 Experiment: a Quicklook Atlas**
Edited by T D Hewson
November 1993

16. **Frontal wave stability during moist deformation frontogenesis**
Part 1. Linear wave dynamics
C H Bishop and A J Thorpe
May 1993

17. **Frontal wave stability during moist deformation frontogenesis**
Part 2. The suppression of non-linear wave development
C H Bishop and A J Thorpe
May 1993

18. **Gravity waves in sheared ducts**
C Bishop and A J Thorpe
November 1993

19. **Potential Vorticity and the Electrostatics Analogy: Quasi-Geostrophic Theory**
C Bishop and A J Thorpe
November 1993

20. **Recent Advances in the Measurement of Precipitation by Radar**
A J Illingworth
April 1993

21. **Micro-Physique et Givrage. Cloud Microphysics and Aircraft Icing**
A J Illingworth
May 1993

22. **Differential Phase Measurements of Precipitation**
M Blackman and A J Illingworth
May 1993

23. **Estimation of Effective Radius of Cloud Particles from the Radar Reflectivity**
N I Fox and A J Illingworth
May 1993

24. **A Simple Method of Dopplerising a Pulsed Magnetron Radar**
A Hau, A J Illingworth and J Eastment
November 1993

25. **Radiation and Polar Lows**
George C Craig
February 1994

26. **Collected preprints submitted to the International Symposium on the Life Cycles of Extratropical Cyclones; Bergen, Norway, 27 June - 1 July 1994**
April 1994

27. **Convective Frontogenesis**
Douglas J Parker and Alan J Thorpe
April 1994

28. **Improved Measurement of the Ice Water Content in Cirrus Using a Total Water Evaporator**
Philip R A Brown and Peter N Francis
April 1994

29. **Mesoscale Effects of a Dry Intrusion within a Vigorous Cyclone**
K A Browning and B W Golding
April 1994

30. **GEWEX Cloud System Study, Science Plan**
May 1994

31. **Parametrization of Momentum Transport by Convectively Generated Gravity Waves**
R Kershaw
February 1995

32. **Mesoscale Modelling Newsletter No 5**
May 1994

33. **Observations of the mesoscale sub-structure in the cold air of a developing frontal cyclone**
K A Browning, S A Clough, C S A Davitt, N M Roberts and T D Hewson
May 1994

34. **Longwave Radiative Forcing of a Simulated Tropical Squall Line**
Imtiaz Dharssi
July 1994

35. **On the nature of the convective circulation at a kata-cold front**
K A Browning
September 1994

36. **Collective preprints of papers submitted to the COST-75 International Seminar on Advanced Weather Radar Systems, Brussels, 20-23 September 1994**
November 1994

37. **Use of satellite imagery to diagnose events leading to frontal thunderstorms: Parts 1 and 11 of a case study**
K A Browning and N M Roberts
November 1994

38. **The role of spaceborne millimetre-wave radar in the global monitoring of ice cloud**
P R A Brown, A J Illingworth, A J Heymsfield, G M McFarquahar, K A Browning and M Gosset
December 1994

39. **Potential Vorticity Inversion**
Michael Ziemianski
October 1994

40. **Theory of mature tropical cyclones; a comparison between Kleinschmidt (1951) and Emanuel (1986)**
Suzanne L Gray
December 1994

41. **Dispersion and removal of pollutants during the passage of an atmospheric frontal System**
N R Gimson
December 1994

42. **The role of snow sublimation in frontogenesis**
D J Parker and A J Thorpe
December 1994

43. **Potential vorticity and the electrostatics Analogy: Ertel- Rossby formulation**
A J Thorpe and C H Bishop
December 1994

44. **Mesoscale aspect of extratropical cyclones: an observational perspective**
K A Browning
January 1995

45. **A Polar Low Outbreak: Evolution and Mesoscale Structures**
T D Hewson, G C Craig and C Claud
February 1995

46. **Generation of near-surface gusts of deep convection**
K Nakamura and R Kershaw
April 1995

47. **Attribution Concepts applied to the Omega Equation**
S A Clough, C S A Davitt and A J Thorpe
June 1995

48. **Parametrization of mixed-phase cloud and precipitation**
Susan P Ballard and M Gerard Hutchinson
June 1995

49. **Short-range forecasting of stratocumulus: Initialization Prediction**
Susan Ballard, Simon D Jackson and B Macpherson
June 1995

50. **Contributions of the JCMM/Dept of Meteorology Radar Group to the 27th AMS Radar Meteorology Conference, Vail October 1995**
June 1995

51. **Cold Pools in Shear**
Douglas J Parker
September 1995

52. **High-resolution analysis of frontal fracture**
K A Browning, S P Ballard and C S A Davitt
September 1995

53. **The Albedo of Broken Cloud Fields: Calculations using a modified two stream radiation code**
Imtiaz Dharssi and Roy Kershaw
October 1995

54. **Parametrization of momentum transport by convection. I: Theory and cloud modelling results**
R Kershaw and D Gregory
November 1995

55. **Variation of frontal structure along a cold front**
K A Browning and N M Roberts
November 1995

56. **Secondary Frontal Waves**
Douglas Parker
December 1995

57. **Objective Fronts**
T D Hewson
March 1996

58. **Mesoscale analysis of the activation of a cold front during cyclogenesis**
K A Browning, N M Roberts and A J Illingworth
June 1996

59. **Investigation of Different Representations of Rain in a 1-d Evaporation Model**
H Swann
May 1996

60. **Parametrization of diabatic processes in the inversion of the omega-equation**
M Athanassiadou and A J Thorpe
June 1996

61. **The Role of the Environmental Flow in the Development of Secondary Frontal Cyclones**
I A Renfrew, A J Thorpe and A Joly
June 1996

62. **Consequences of the geostrophic momentum approximation on barotropic instability**
S Malardel, A J Thorpe and A Joly
June 1996

63. **Contributions to the AMS/RMS Conference on Mesoscale Processes**
Reading, 9-13 September 1996

64. **Vorticity and Potential Vorticity in Stratified Flows Interacting with an Isolated Obstacle**
Jorge A Gutiérrez and A J Thorpe
September 1996

65. **Triple Point Development: Two Case Studies**
Douglas Parker
September 1996

66. **Radar observations of wind-shear splitting within evolving atmospheric Kelvin-Helmholtz billows**
D Chapman and K A Browning
April 1997

67. **Cold Frontal Structure derived from radar wind profilers**
K A Browning, D Jerrett, J Nash, T Oakley, N M Roberts
May 1997

68. **The dry intrusion and its effect on the frontal, cloud and precipitation structure of extratropical cyclones**
K A Browning - Text of invited special lecture at the Spring Conference of the Meteorological Society of Japan, University of Tsukuba, 22 May 1997

69. **Met. Office Unified Model data, diagnostic graphics programs, and other observational data available from the JCMM through the aegis of the Universities Weather Research Network UWERN.** Plus supplement.
Peter Panagi and Ed Dicks
June 1997

70. **Contributions of the JCMM/Dept of Meteorology Radar Group to 28th AMS Radar Meteorology Conference.** Austin, Texas, September 1997

71. **Sensitivity of short-range weather forecasts to local potential vorticity modifications**
Meral Demirtas and Alan Thorpe
July 1997

72. **Objective identification of frontal wave cyclones**
T D Hewson
August 1997

73. **Attribution and its application to mesoscale structure associated with tropopause folds**
A J Thorpe
September 1997

74. **The Role of the Environmental Flow in the Development of Secondary Frontal Cyclones**
Ian A Renfrew, Alan J Thorpe and Craig H Bishop
September 1997

75. **Potential Vorticity: A short history of its definitions and uses**
Alan J Thorpe and Hans Volkert
September 1997

76. **Superposing Semi-Geostrophic Potential Vorticity Anomalies**
H R Birkett and A J Thorpe
September 1997

77. **Short period forecasting of catchment-scale precipitation. Part 1: the role of Numerical Weather Prediction**
M A Pedder, M Haile and A J Thorpe
September 1997

78. **Verification of the Tracking Technique Used in an Experimental Cloud Motion Wind Inferring System**
Z Wang, K A Browning and G A Kelly
October 1997

79. **A Preliminary Study of Fourier Series Analysis for Cloud Tracking with GOES High Temporal Resolution Images**
Z Wang
October 1997

80. **Analysis of an ex-tropical cyclone after reintensifying as a warm-core extratropical cyclone**
K A Browning, G Vaughan and P Panagi
November 1997

81. **A JCMM overview of FASTEX IOPs**
S A Clough, H W Lean, N M Roberts, H Birkett, J-P Chaboureau, R Dixon, M Griffiths, T D Hewson and A Montani
November 1997

82. **Programs for PV Inversion and modification**
Meral Demirtas
December 1997

Met Office Joint Centre for Mesoscale Meteorology Department of Meteorology
University of Reading PO Box 243 Reading RG6 6BB United Kingdom
Tel: +44 (0)118 931 8425 Fax: +44 (0)118 931 8791
www.metoffice.com